

Project Title

Scale-Up and Demonstration of Fly Ash Ozonation Technology

Sixth Quarterly Technical Report
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ABSTRACT

This is the fifth quarterly report under DOE Cooperative Agreement No.: DE-FC26-03NT41730. Due a number of circumstances, mostly associated with subcontractor agreements, the actual beginning of the project was delayed from its original award date of March 5, 2003. DOE's Project Manager was kept informed (verbally) by PPL's Project Manager throughout this period.

Because of this delay, this is the sixth quarterly report and it refers to the time period from August - October 2005. During this period, the project team has completed the analyses of data from the onsite ozonation tests, as well as working on the engineering/economic task and preparing the final report.

No significant issues or concerns are identified.

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INTRODUCTION

Objectives

PPL has lost concrete marketability for much of its ash from the Montour power station due to high carbon content. The objective of the project is to demonstrate ash ozonation technology on a utility site, with minimum modification to existing plant equipment and operations and to confirm the process effectiveness through a complete battery of technology performance and concrete quality tests, to develop a plan for effective implementation at the PPL Montour station and for technology transfer to other U.S. coal-fired plants.

EXECUTIVE SUMMARY

Scope of Work

Based on the results of pilot testing performed during the Spring/Summer of 2002 at the Fuller Bulk Handling (FBH) test facility, the project team determined that air merge blending is the technology of choice for fluidization/ozonation of fly ash. In Task 1 of the project, the technology will be deployed and tested at PPL's Montour Steam Electric Station, where it will be integrated with existing ash handling systems. In Task 2 technical and economic analyses will be conducted for a full-scale, commercial design of the technology. Task 3 is proposed as a “documentation” task and will produce a Final Report to DOE. These tasks are described below in more detail.

In this project, PPL will supply a continuous stream of the high-carbon problem ash, as well as ash handling equipment at the station (e.g. silos, fans, etc.). Ash from other (non-Montour) sources will also be obtained and tested to evaluate the influence of different ash parameters on the effectiveness of the ozonation technology. WEDECO will supply a new SMA50 ozone generator capable of treating large quantities of ash.. A matrix of contacting conditions and carbon/ozone stoichiometries will be tested and the results compared. Concrete testing of treated ash samples will be performed by CMT laboratories and supporting analyses of the ash will be carried out at the Brown University research laboratories. A plan will be developed for implementation of the optimal process at Montour and for technology transfer to other U.S. generating plants. Finally, design guidelines will be developed to allow for an effective “jump” into commercial development.

EXPERIMENTAL

Tasks Description

The proposed scope of work will be broken down into the following major tasks:

TASK 1 – Design/Deploy/Test semi-commercial fluid bed system at Montour Station

Objective – Conduct semi-commercial scale test of fluidization/ozonation of fly ash at PPL's Montour Station using FBH's Airmerge™ blender and WEDECO's ozonation technologies. Building upon previous tests and development by the project team, FBH will design and fabricate a 42" diameter Airmerge™ batch blender for gas/solids contacting. WEDECO will supply a new SMA50 ozone generator capable of producing 100 lb/day of ozone operating on air. The system will be integrated with existing ash handling systems at Fly Ash Storage Silo #1 at PPL's Montour Station, as illustrated in Figure 1. Off-gases will be pre-filtered and sent to an ozone destruct unit prior to discharge to atmosphere. FBH will complete the installation approximately 5 months from the start of the project.

Six fly ashes of varying characteristics will be tested in the system to develop a range of system operating parameters. The installed system will accept ash from the silo, "ozonate" the ash in batches, and loadout the ash to PD rail cars through an existing airslide. This streamlined material flow will allow for ash throughput of about 10 tons/day. Testing is anticipated to last approximately five weeks.

The following activities, or subtasks, will be conducted in this task.

- Design and fabricate 42-inch Airmerge™ blender and SMA50 ozone generator.
- Prepare test matrix.

- Deploy fluidization/ozone generator system.
- Interface with Montour ash handling systems (storage silos, dry ash loadout, etc.)
- Conduct parametric tests
 - Operating parameters
 - *fluidization/aeration velocities*
 - *vibratory fluidization enhancement*
 - *raw ash quality (different sources and carbon content)*
 - *ozone reaction stoichiometry (gm-ozone/kg-ash)*
- Conduct ash and concrete analyses (foam index, mortar air-entraining tests, petrography, trial batches for short and extended mixing times)
- Results documentation
- Reporting to DOE

TASK 2 – Design Full Scale-up for Montour Station and Development of Generic Design Guidelines

Objective – Develop design modifications for the full scale-up of the ash fluidization/ozonation system based on overall performance considerations from Task 1. This will serve to demonstrate low-cost retrofit potential to existing systems at normal operating conditions. Develop generic design guidelines addressing technical and cost considerations, for commercializing the technology. The following activities, or subtasks, will be conducted in this task.

- Design modifications for existing systems
- Develop design guidelines for wide-applicability ozonation systems
- Cost/Economic analyses
- Results documentation
- Reporting to DOE

TASK 3 – Final Report

Objective – Provide full documentation of project results and develop design guidelines, cost estimates commercialization potential for the technology. This will include:

- Design criteria
- Performance expectations
- Cost
- Applicability
- Deployment and operation

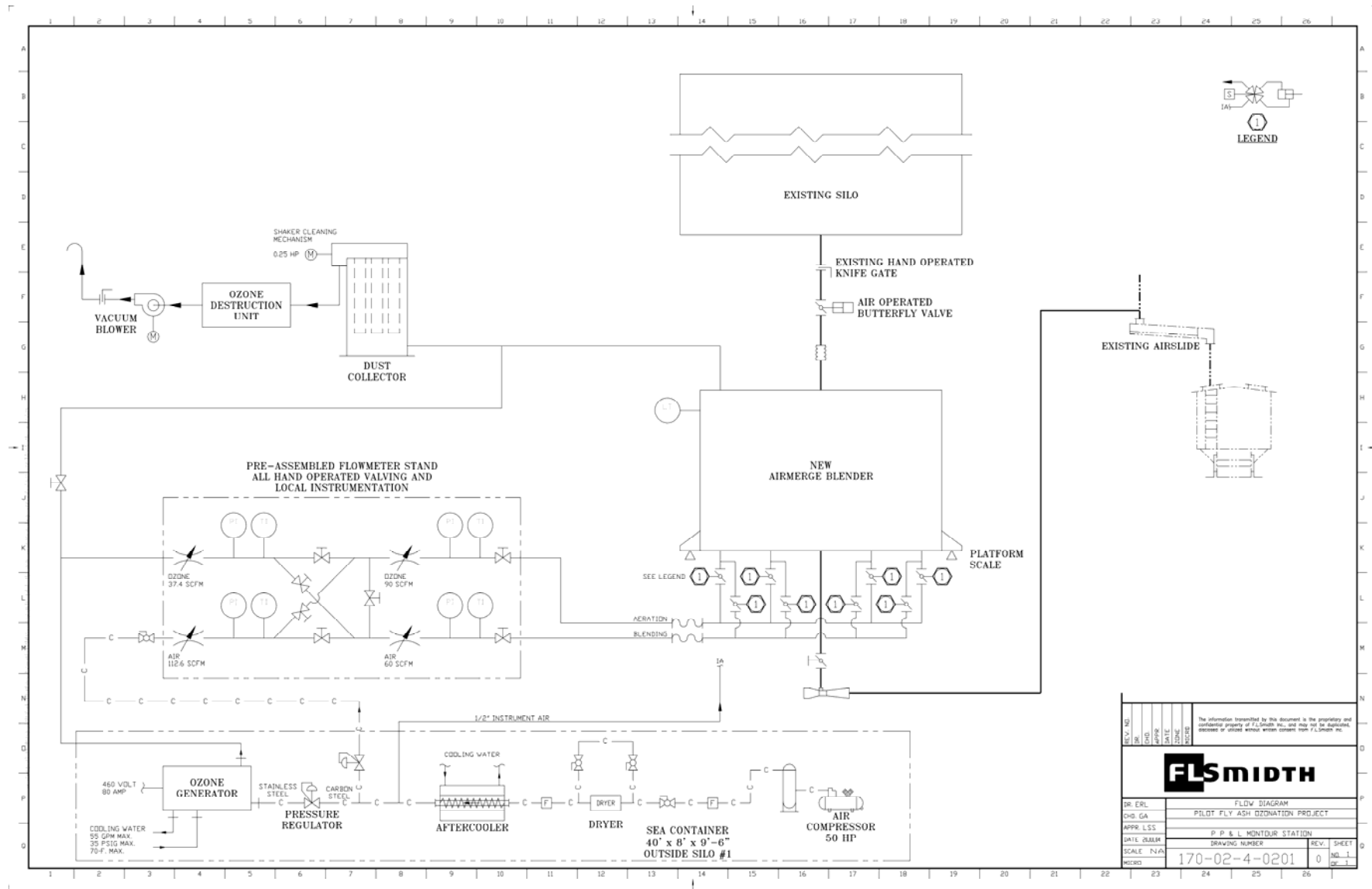


Figure 1 - Task 1 Semi-commercial scale installation of fluidization/ozonation technology at Montour (revised)

RESULTS AND DISCUSSION

The project has progressed on schedule and without any significant issues of concern throughout this quarterly period (July - September). The major activities during this period were the completion of the data analyses from the test matrix at Montour SES, development of engineering/economic evaluation and the preparation of the Final Report

The on-site test program was started on February 22, 2005 and ended on March 21, 2005. Analyses of all the parametric test results are currently underway. Dedicated concrete testing of selected treated ashes was also conducted during this period.

The flow chart below (figure 2) provided a general approach for the first batch of tests intended to determine the impacts of the major operating parameters (fluidization, ozone levels, contact times, bed height, velocities). This served as a guideline to “move through” the initial parametric tests and ensure that we are thorough as well as efficient. It essentially shows the logic behind the first phase of testing. Based on the “lessons learned” from the first batch of parametric tests, the actual test program is summarized in figure 3. It identifies the ash source, type of fluidization approach (Airmerge mode vs. conventional fluid bed mode), as well as other relevant parameters (O₃ concentration, mixing flow “intensity” (max vs. min fluidization))

Figure 2. Initial Test Matrix Logic Flow Chart

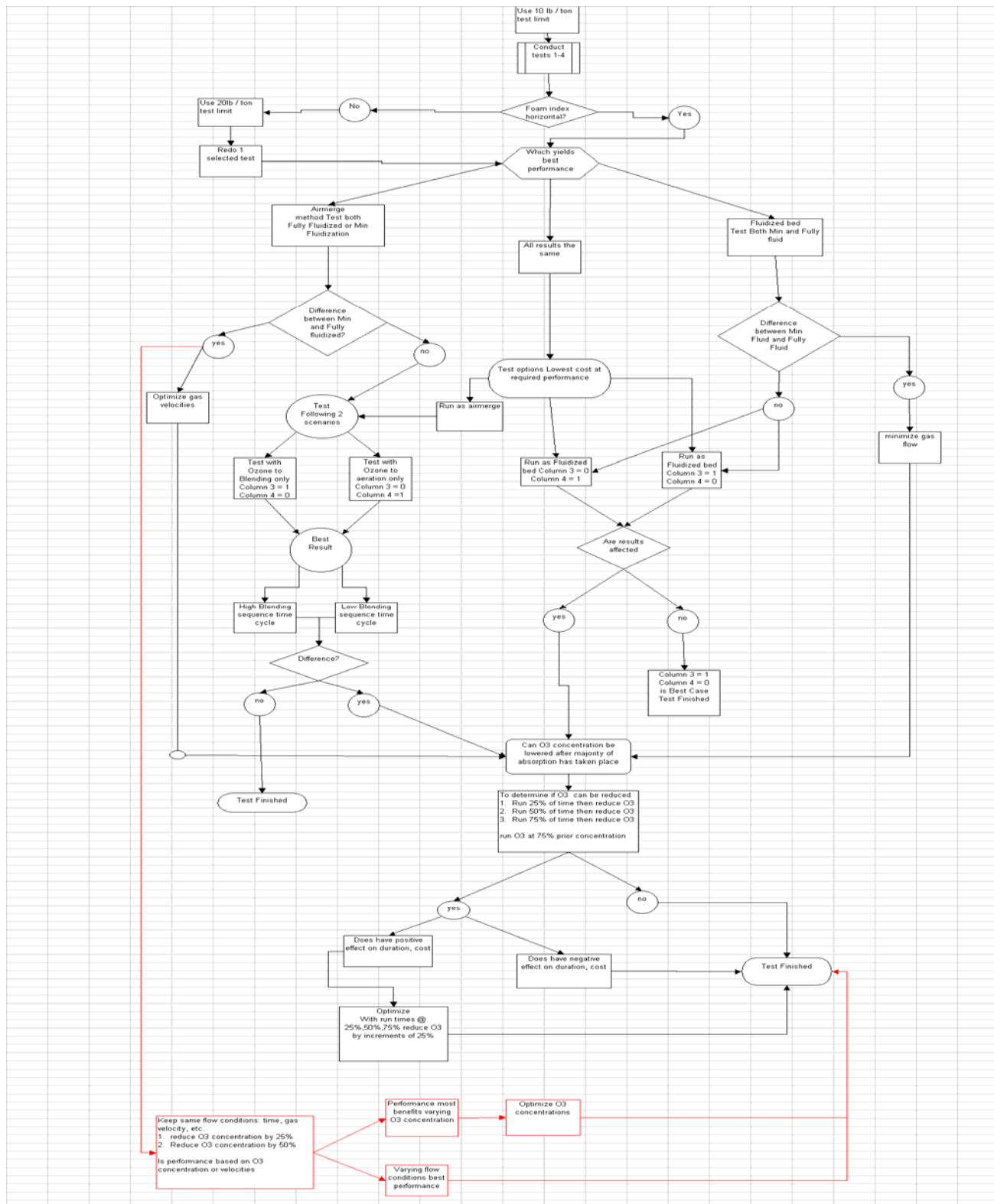


Figure 3. Final Test Program

Test #	Sample	Test Description	O3 Concentration	O3 Flow	Total Flow
			%	SCFM	SCFM
1	PPL Hard Grind Ash	Max Airmerge	2	20	20
2	PPL Hard Grind Ash	Min Airmerge	2	13	13
3	PPL Hard Grind Ash	Max Fluidized	2	20	20
4	PPL Hard Grind Ash	Min Fluidized	2	8	8
5	PPL Hard Grind Ash	Max Fluidized	1	20	20
6	PPL Hard Grind Ash	Max Airmerge	2	8	20
7	PPL Hard Grind Ash	Max Fluidized	0.5	20	20
8	PPL Hard Grind Ash	Max Fluidized	2	20	20
9	PPL Reg Grind Ash	Max Fluidized	2	12	35
10	PPL Reg Grind Ash	Min Fluidized	2	18	18
11	PPL Reg Grind Ash	Max Airmerge	2	12	35
12	Dairyland, Class C	Max Airmerge	2	18	70
13	PPL Reg Grind Ash	Max Fluidized	2	18	35
14	Dairyland Genova	Max Fluidized	2	16	26
15	Dairyland Genova	Max Airmerge	2	16	26
16	Dairyland Genova	Min Fluidized	2	16	20
17	5% AC & STI Ash	Max Fluidized	2	12	12
18	1.5% AC & STI Ash	Max Fluidized	2	12	12

Ozonation and Concrete Test Results

The table in figure 4 below summarizes the results of all the tests in the test matrix including Foam Index and concrete performance (air entrainment) tests. As already stated, the FI test is an indicator of how a particular ash will behave in concrete with respect to its air entrainment performance. While manufacturers often rely on the FI successfully, there is a need to validate such results. As described in section 4, air entrainment tests were conducted to provide such validation in this program. AEA uptake was also determined for several of the ashes. AEA uptake indicates the amount of AEA required for the mix, hence an indicator of chemical costs.

Test #	Sample	LOI	Foam Index	Foam Index	% AEA Untreated ash	% AEA Ozonated ash	% Air	Air Loss rate
			Untreated Ash	Ozonated Ash [end test]	divided by	divided by	at end of test	
		%	vol-% AEA ml/g-ash	5 vol-% AEA ml/g-ash	%AEA Portland Cement	%AEA Portland Cement	%	% per 90 min
1	PPL Hard Grind Ash	5.2	0.16	0.04	600			
2	PPL Hard Grind Ash		0.07	0.04				
3	PPL Hard Grind Ash		0.1	0.02			4	4.2
4	PPL Hard Grind Ash		0.11	0.01				
5	PPL Hard Grind Ash		0.11	0				
6	PPL Hard Grind Ash		0.09	0.01	240			
7	PPL Hard Grind Ash	2.5	0.09	0.03	240		4.6	3
8	PPL Hard Grind Ash	3	0.1	0.03	280		4.1	2.9
9	PPL Reg Grind Ash	3.2	0.14	0.05	240		3.9	4.1
10	PPL Reg Grind Ash		0.14	0.04			4.4	2.2
11	PPL Reg Grind Ash	4.2	0.14	0.04	500		3.1	3.1
12	Dairyland, Class C	0.8	0.08	0.02			6.7	1.3
13	PPL Reg Grind Ash		0.13	0.03			4.8	3.7
14	Dairyland Genova	4.2	0.24	0.06			5.1	1.1
15	Dairyland Genova	4.2	0.2	0.02				
16	Dairyland Genova	4.2	0.18	0.02			3.7	1.8
17	5% AC & STI Ash		0.9	0.65				
18	1.5% AC & STI Ash		0.36	0.04	600		3.5	3.3
CONTROL ASH								
Class F	Baltimore STI	0.9	0.02		180		3.2	3.2
Class F	Baltimore STI	0.9	0.02		220		4.8	3.3
Class C	Coal Creek	0.5					6.7	1.3

Figure 4. Ozonation test results summary. Foam Index, %AEA and air entrainment

Acceptability of fly ash to concrete manufactures is a function of various criteria, including such parameters as LOI, AEA uptake and air entrainment performance. While LOI must adhere to ASTM C 618 (<6%), other parameters can vary among different manufactures and ash types. For this reason, FI results were complemented with %AEA (Class F ashes) and % air entrainment (Classes F and C ashes). Finally and most importantly, “control ashes” from current, market-accepted suppliers, were used as references against which, the ozonated ashes were compared.

Next Reporting Period

Key tasks for the next reporting period

- Complete analyses of economic analyses
- Prepare Final report

CONCLUSIONS

Summary Conclusions from Test Program Results

Foam Index (FI) results for all the tests at the Montour station, as well as concrete air entrainment and AEA uptake tests have been reviewed. The following summarizes the data assessment at the present time.

Ashes tested - Class F, Class C, Class F+ Activated Carbon (1.5% and 5%)

Ozonation treatment was successful on all ashes with the exception of the STI + 5% AC mix.

This conclusion is based on the Foam Index results and confirmed by concrete (air entrainment) and AEA tests

For all ashes the treatment dosage remained in the range of 0.5 to 2 lbs O₃/1000lbs ash, with acceptable performance mostly under 1lbs O₃/1000lbs ash.

Mode of fluidization (airmerge vs. simple fluid bed) seemed to have negligible impact

O₃ concentration seemed to have negligible impact on performance. Note however that O₃ concentrations in the gas flow never exceeded 2% throughout the test program

The Class F + 5% AC mix was not successfully “deactivated” by O₃. At present it is not clear whether this is real limitation of the technology or simply a result of a single test with no opportunity to optimize. Future work at lab scale may help understand this better

From the conclusions and observations above, the following guidance was used for task 2 (engineering scale up and economic analyses)

O₃ Dosage: 0.5 -1 lbs O₃/1000lbs ash

O₃ concentration from generator not critical

Contact Mode: Simple Fluidized Bed (no need for Airmerge blending features)

Gas Flow/Velocity: Not critical based on tests results. Scale up design should be based on experience between the range of MAX and MIN fluidization test results.

Sample ash buckets were retained for concrete testing at several points during the tests. These tests have confirmed the FI trends observed during the ozonation tests that indicated the successful “deactivation” of the ash. In other words, air entrainment and AEA uptake for the treated ashes have confirmed their suitability for the concrete market based on direct comparison with “control” or reference ashes (Class F and C ashes currently being sold)

- Class F – STI Baltimore.
- Class C – Coal Creek

The test results for the STI ash “contaminated” with Activated Carbon were very encouraging as well. We can say that for the 1.5% AC sample (a high but reasonable concentration of AC possibly to be found in “real” mercury control scenarios), the ozone treatment seemed highly effective. The other sample (an extremely high 5% AC concentration likely not to be found in “real” Hg control scenarios) needs further analyses.

REFERENCES

None for this reporting period.

LIST OF ACRONYMS AND ABBREVIATIONS

DOE	Department of Energy
ESP	Electrostatic precipitator
FGD	Flue gas desulfurization
ID Fan	Induced draft fan
FI	Foam Index
cfm	Cubic feet per minute
kW	Kilowatt
MW	Megawatt
NETL	National Energy Technology Laboratory
O&M	Operating and Maintenance
PC	Pulverized coal
PRB	Powder River Basin
FBH	Fuller Bulk Handling Division
PPL	PPL Generation, LLC
EPRI	Electric Power Research Institute
EES	Energy and Environmental Strategies